acts of Congress and Presidential proclamations in creating and recognizing the Lassen Peak National Forest and Lassen Peak National Monument have given the name *Lassen Peak* a status of high rank in the geologic annals of the Cascade Range. The area has recently been set apart as the Lassen Volcanic National Park.

The name Lassen Peak, according to the United States Geological Survey, *is the only authorized form* on maps, reports, and gazetteers, from the Whitney Geological Survey of California in 1865, to the Geomorphic map of California and Nevada published by the Earthquake Investigation Commission, as well as on the latest map issued by the Forest Service.

Peter Lassen, the sturdy pioneer who guided many an early settler to the sunny lands of the Sacramento, lies buried in a lonely grave in Lassen County. A small, crumbling monument 30 miles from the peak marks his final resting place, but his greater and more enduring monuments are the county and peak named in his honor by a grateful people. The snow-capped Lassen Peak has piloted many an immigrant to the mountain pass.

In the early days of the Pacific Railroad surveys some pious monk called the peak St. Joseph's Mountain, but the names Lassen's Peak and Lassen's Butte soon came into general use. Whitney has shown the inappropriateness of the French term butte, which, translated exactly, means knoll. As Lassen never owned the mountain, in later years the possessive form of the name was dropped, and to correct an illicit tendency to wander from well-established usage the United States Geographic Board, in its decision of October 9, 1915, officially recognized the fact that the name of the mountain was *Lassen Peak*, not Mount Lassen.

AN ERUPTION OF LASSEN PEAK.

By ANDREW H. PALMER, Observer.

[Dated: Weather Bureau, San Francisco. Cal., July 14, 1916.]

Lassen Peak, the only active volcano within the United States, is located in the northeastern part of California, latitude 40° 30′ N., longitude 121° 30′ W., at a distance of 210 miles north-northeast of San Francisco. Rising 10,437 feet above sealevel, it is a conspicuous feature of the landscape. It is the southernmost peak of the Cascade Range, and like most of the mountains forming that range, it is of volcanic origin. While some geographers consider it a part of the Sierra Nevada, its origin and structure, as well as its position, justify its inclusion with the Cascades. These peaks have all been active volcanoes recently, geologically speaking, though measured in terms of years they have long been dormant.[1] Judging from the erosion on the sides of its old cone, Prof. R. S. Holway, of the University of California, believes that Lassen Peak had been quiet for a thousand years preceding its present period of activity. However, Cinder Cone, 10 miles to the northeast, and the Chaos Crags, at the northwest base of Lassen, have been in eruption as recently as 200 years ago.

On May 30, 1914, residents in the vicinity of the Peak were astonished by the appearance of smoke and steam rising from its summit. An investigation made the following day by a ranger in the United States Forest Service revealed the fact that a new crater, 25 by 40 feet, had been formed within the old crater, and that the products of the eruption, consisting of dust and bits of rock, were scattered upon the snow for a distance of 300 feet from the new vent. More eruptions followed, their violence increasing and the size of the crater growing with each successive outburst. The activity culminated with the two great eruptions of May 19 and 22, 1915. While eruptions have continued sporadically ever since, the climax of the present period of activity seems to have been passed. Outbursts continue to become fewer and less violent, much to the disappointment of scientific observers, but greatly to the satisfaction of the residents of the region. A total of about 225 eruptions have been observed. The eruptions during 1916, to July 15, appear to verify the prediction made at the beginning of the year by J. S. Diller, of the United States Geological Survey, that as an active volcano Lassen Peak is again on the decline. Figures 1–5, inclusive, are photographs taken at 10-minute intervals by Mr. Chester Mullen, at a distance of 5 miles from the summit. They show various stages in a typical eruption, that of October 6, 1915.

Certain phases of the present period of Lassen Peak's activity have been investigated and described by authorities in their respective branches. The geological and the physiographical aspects have naturally received the most attention. The physics and the chemistry of these eruptions have been investigated by representatives of the Carnegie Institution of Washington, but their report has not yet been made public. The meteorological and the seismological aspects have apparently been neglected, though many incidental references have been made to them. Certain facts have been observed which are at least of interest, if not of importance, in these two fields. As already indicated, opportunities of this kind are infrequent in the United States, compared with the average life of man, and it is quite probable that another such opportunity will not occur during the present generation. Feeling that certain considerations are worthy of record, the following observations have been collected from all available sources.

METEOROLOGICAL CONSIDERATIONS.

The meteorological aspects of a volcanic eruption are necessarily external to the crater, and are involved principally with the matter emitted. In the case of Lassen Peak certain common forms of matter are known to have been present. The dust and ash consisted entirely of rock fragments, pulverized as by great pressure, and showed no evidence of combustion such as might produce residual cinders. These fragments varied in size from microscopic bits to a mass 15 feet in diameter and weighing more than 60 tons. It appears that steam at high temperature accompanied most of the observed eruptions, and this on condensing formed the visible water vapor which when soiled by the dust particles gave the appearance of smoke. On mixing with the surrounding air this mass cooled, part of the water being precipitated as rain. Following the first eruption, that on May 30, 1914, icicles formed on the projecting rocks on the inner side of the crater. While Diller believes that a considerable volume of water in the form of steam was ejected, the phenomenon was in no sense a geyser, and there is no evidence of surface erosion due to excessive precipitation. Such rainfall must have been very local, perhaps

[1] For historical data relating to volcanic eruptions in the United States consult: *Whitney, J. D.* The United States. Boston, 1889. pp. 113-116.

Fig. 1.

Fig. 2.

Figs. 1 to 5.—Views of the Lassen Peak eruption on Oct. 6, 1915, taken at 10-minute intervals from a point 5 miles distant. (Photos by Chester Mullen.)

FIG. 3.

FIG. 4.

FIGS. 1 to 5.—Views of the Lassen Peak eruption on Oct. 6, 1915, taken at 10-minute intervals from a point 5 miles distant. (Photos by Chester Mullen.)

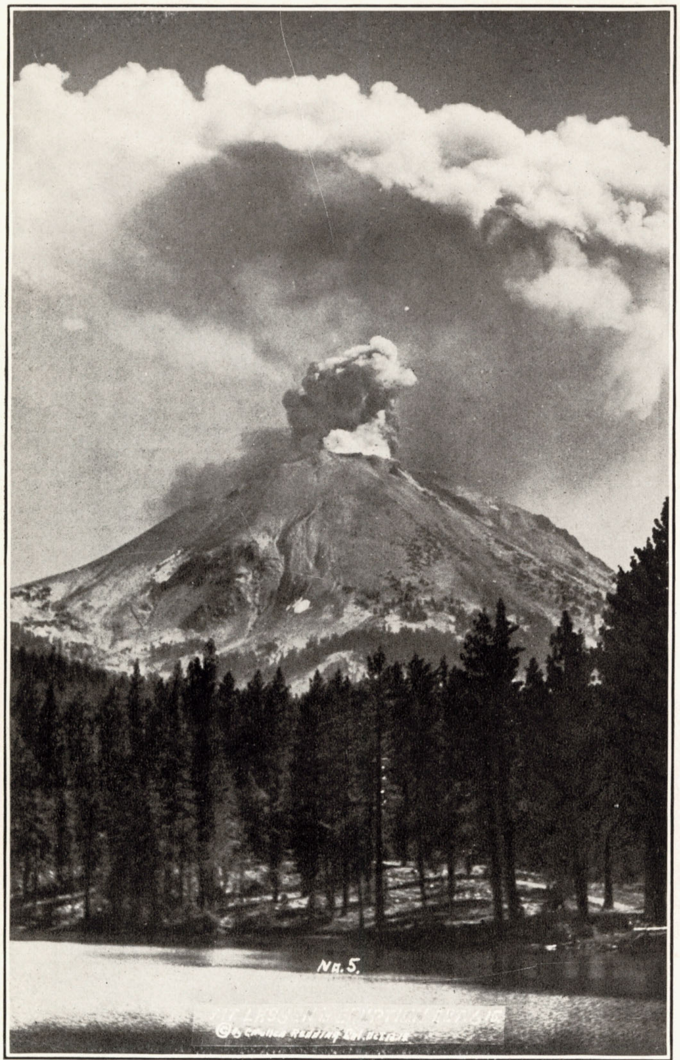

FIG. 5.—Last of series of views of the Lassen Peak eruption on Oct. 6, 1915. (Cf. figures 1-5.)

FIG. 6.—The great eruption of Lassen Peak on May 22, 1915, as seen from Anderson, Cal., 50 miles distant. (Photo by R. I. Myers.)

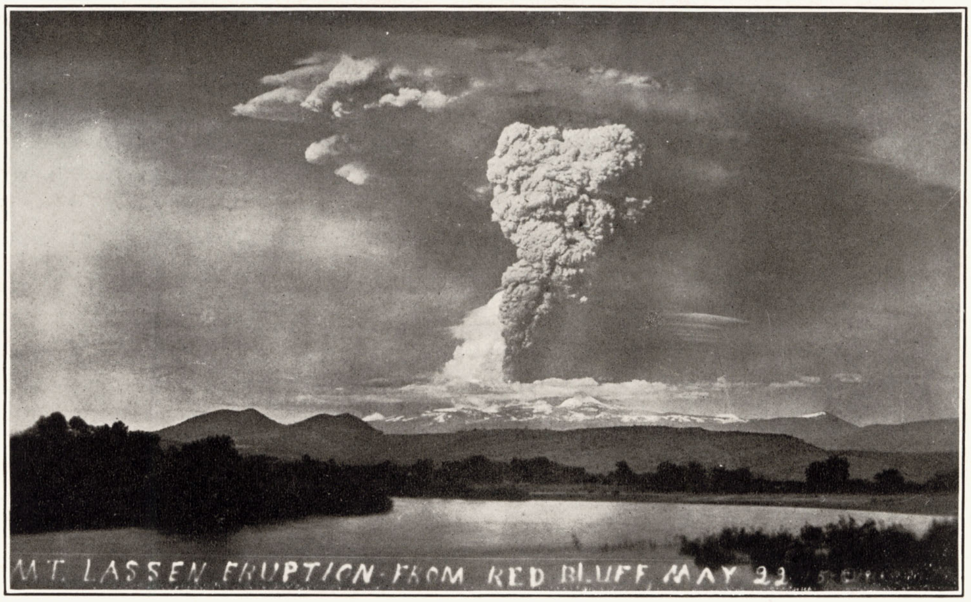

FIG. 7.—A second view of the great eruption of May 22, 1915, as seen from Red Bluff, Cal., shortly after the time represented in figure 6. (Photo by R. E. Stinson.)

FIG. 8.—Another eruption when the wind increased with the altitude. (Photo by Tuck.)

FIG. 9.—An eruption when the strong wind dispersed the smoke and ash before they could form a vertical column. (Photo by Tuck.)

FIG. 10.—Summit of Lassen Peak, showing the crater formed by the eruption of May, 1914. (Photo on June 20, 1914, by B. F. Loomis.)

limited to the slopes of the peak itself. Flames[2] were reported to have been seen at various times, but it is believed that on some of these occasions the reddish color was due to sunshine reflected by clouds. In addition to the dust and water vapor ejected it is probable that there was considerable sulphur in the gaseous state. The latter is characteristic of a volcanic region. Even the fumaroles, which are so common in the great lava fields which form the northeastern part of California and a portion of Oregon and Washington, give off gases containing sulphur fumes. It was therefore to be expected that Lassen Peak should eject sulphur gas. The quantity must have enormous, for on one occasion, when a northerly wind was blowing at the time of an eruption, sulphur fumes were detected 15 miles to the south, and there are no sulphur fumaroles in that direction. Sulphur has been and still is being deposited in a solid state on the inner portions of the crater which are in contact with the charged vapors. That the escaping gases were not poisonous, was shown by the survival of a party of 10 men who were surprised by an eruption while peering into the crater on June 14, 1914.

The temperature of the escaping material is interesting meteorologically because of the effects produced. Observers testify that some of the matter ejected in the great eruption on the night of May 19, 1915, was luminous,[2] a condition requiring a temperature estimated at 600° to 900°C. Part of the superheated gas and ash escaped from beneath the lava cap and did serious damage on the northeast side of the mountain.[3] The sudden melting of the snow produced a flood which destroyed everything in its path of 10 miles in length and exceeding a mile in width. Forest trees were uprooted or broken off at the ground and distributed in parallel rows at the bottom of the slope. Other trees, not destroyed by the rush of water, were seared by the hot blast. The United States Forest Service reported that two forest fires were thus kindled, probably the only cases of such origin which have occurred in the United States since the Forest Service was originated.

The principal fact of meteorological interest associated with an eruption is that related to the wind velocity and direction aloft. Particles freely suspended in the air necessarily travel with the wind, that is, at the same velocity and in the same direction as the surrounding air. An eruption, therefore, produces a graphic cross section of the atmosphere, as far as wind velocity and direction are concerned. Figure 6 is a photograph taken by Mr. R. I. Myers of the eruption of May 22, 1915, the greatest eruption that has occurred. It was taken about 50 minutes after the first evidence of an outburst was noticed.

On this occasion, Mr. N. M. Cunningham, Observer, United States Weather Bureau, at Red Bluff, estimated by means of a nephoscope that the top of the visible column reached at least 20,000 feet above the summit of the mountain, or approximately 6 miles above sea level. The photograph was taken from Anderson, 50 miles distant from the volcano, and the camera was pointed eastward. The top of the smoke column was observed as far distant as Marysville, 80 miles to the south. The mushroom-like structure of the column shows the relatively stagnant condition of the atmosphere, with little or no horizontal movement. At Red Bluff at 5 p. m. on that day the wind was south, with a velocity less than 6 miles per hour. Though it can not be noted from the photograph, the wind aloft had a westerly component. Some of the dust which had risen to the higher levels was carried eastward as far as Winnemucca, Nev., a distance of about 200 miles. On that day the weather of northern California was dominated by a HIGH whose center was off the coast. The cross section is therefore one of an anticyclone. On June 26, 1914, when a slight eruption occurred under conditions of absolute calm, the dust was entirely precipitated within a radius of a mile. It is apparent, therefore, that wind is the principal element which determines the distribution of dust and ash resulting from a volcanic eruption. Moreover, the wind on certain occasions stirred up the dust, ash, and snow on the sides of the peak, and gave a false impression that new craters had been formed. Figure 7 is a photograph taken by Mr. R. E. Stinson in Red Bluff. It is another view of the great eruption of May 22, 1915, and was taken shortly after the photograph shown in figure 6, and after the westerly wind aloft had begun to destroy the gently rounded edges of the column. A second puff of smoke is seen rising in the column, most of that produced in the first outburst having drifted eastward. Figure 8 is a photograph of another eruption, and indicates graphically the increase of wind velocity with height. Figure 9 is a view of still another eruption which occurred when the wind was so strong that the dust and ash were dispersed before they formed a vertical column. It is sometimes stated that wind transports about as much material as do streams. These illustrations show how the finely attenuated products of a volcanic eruption can be carried in suspension by the atmosphere.

Though it is apparent from the photographs that considerable quantities of material were ejected into the atmosphere by the numerous outbursts of Lassen Peak, there has been no widespread production of a volcanic dust veil, or high haze, such as followed the great eruptions of Krakatoa, Mont Pelée, and Katmai. Compared with the latter, the activity of Lassen Peak has been relatively slight. The effects upon the atmosphere have been local, and even the dust veils have been limited to 200 miles. No effect upon the weather was apparent, though the uninformed have attempted to explain various abnormalities in California weather during the past two years as being due to the activity of Lassen Peak. Moreover, there was no evidence of suction or cyclonic effects produced by the drawing in of air laterally to take the place of highly heated air rising vertically, such as is occasionally observed over forest fires. In figure 7 it is apparent that even the cumulus clouds, which form every calm summer afternoon in the mountain regions, were undisturbed by lateral currents.

SEISMOLOGICAL CONSIDERATIONS.

In the popular mind earthquakes and volcanoes are closely associated. However, there is still some disagreement among authorities as to the nature of the relation. While in the Hawaiian Islands volcanoes and earthquakes are intimately associated, the Milne-Omori investigation of 8,300 Japanese earthquakes occurring between 1885 and 1892 showed little relation between earthquakes and volcanoes. Only about 3 per cent of Japanese earthquakes are of volcanic origin. Traditions among the North American Indians associated earth tremors with eruptions of the now dormant Cascade volcanoes. On the other hand, Humboldt found a tradition among the natives of South

[2] As the nearest observers were 20 miles away flames could not be distinguished with any degree of certainty. Much more definite reports, well authenticated, state that flashes of light and cloud glows were visible and that ejected luminous bodies were seen flying through the air.—*J. S. Diller.*

[3] The hot ashes falling on the snow on all sides of the peak melted the snow, as at the head of Lost Creek, producing small flows of mud in all directions down the upper slopes; but *disaster occurred only where* the blast of hot gas was shot from beneath the new lava lid down the northeast slope into the great mass of snow that had accumulated for years, and instantly converted it into a deluge.—*J. S. Diller.*

America to the effect that so long as the volcanoes in their neighborhood were active, no danger from earthquakes need be feared, but if they remained quiescent for a long-continued period severe earthshocks might be anticipated. In a manner the volcano acted as a safety valve, according to the tradition. The presence of an active volcano in California naturally invited an investigation to determine whether or not it was related to earthquakes.

Of the 225 or more observed eruptions of Lassen Peak to date, there is no authentic record of a single sensible earthquake occurring in northern California simultaneously with such an outburst. Press dispatches at various times have announced the occurrence of destructive shocks at the times of these eruptions, but when subsequently investigated none of these reports could be verified. Shortly before the first outburst of Lassen Peak, in May, 1914, a moderate shock occurred in the vicinity of Lassen; two other shocks occurred during 1915. This is about the average frequency, and since none of these occurred on days of eruptions it is believed that they were of tectonic origin, like most California earthquakes. United States forest rangers on duty in the vicinity of Lassen at the times of eruptions heard the escaping steam and the falling stones, but reported no rumbling or subterranean noises, nor did they feel any earthquakes. A letter recently addressed to the United States forest supervisor at Mineral, 10 miles from Lassen Peak, brought the following reply:

> Several very slight earthquake shocks were felt here last summer (1915) and in 1914. They did not, however, occur simultaneously with eruptions of Lassen Peak, and to the best of our knowledge there is no relation between earthquakes and volcanic eruptions in this vicinity. It is true, of course, that the ground in the near vicinity of the mountain is felt to tremble slightly during a violent eruption, but it is doubtful if this is a true earthquake shock.

It is probable that the latter tremors are simply local vibrations similar to those produced by the passage of a railroad train and are therefore not earthquakes in the usual sense.

The cause of the present activity of Lassen Peak is now believed to be the immeasurable pressure of expanding lava rising from below and not the explosive action of steam, as in the case of some other volcanoes. Figure 10 is a photograph of the crater of Lassen Peak taken by Mr. B. F. Loomis on June 20, 1914. Prof. Holway finds it difficult to conceive of steam pressure uplifting so evenly a broken and jagged mass of rock. Diller believes that, although the visible activity is limited to near the summit of the peak, the new lava was forced in a hot, viscous state to the surface, where it spread and overflowed the crater rim. Hot springs and solfataras in the vicinity of the Peak show no evidence of increased activity.

CONCLUSION.

The present cycle of Lassen Peak's activity as a volcano appears to be about complete. While future eruptions will be observed with interest, it is believed that they will be relatively feeble and infrequent. An active volcano in the United States is such a rare phenomenon that it is worthy of careful observation from every point of view. While an active volcano is of primary interest to the geologist and the physiographer, it is of at least secondary importance to the meteorologist and the seismologist. Progress in every field demands the recording of all observations available. Those facts of peculiar interest in meteorology and seismology have been collected and reassembled in the foregoing.

BIBLIOGRAPHY.

Recent articles on the present activity of Lassen Peak have been published by the following:

(1) *W. H. Storms* in Mining and Scientific Press, July 25, 1914.

(2) *R. S. Holway* in University of California Publications in Geography, v. 1, no. 7, August, 1914, pp. 307–330, plates 32–36.

(3) *J. S. Diller* in Bulletin of the Seismological Society of America, v. 4, no. 3, September, 1914.

(4) *R. S. Holway* in Popular Science Monthly, March, 1915.

(5) *J. W. Rushing* in The Dam, July & September, 1915.

(6) *R. S. Holway* in Sunset Magazine, August, 1915.

(7) *J. S. Diller* in Bulletin of the Seismological Society of America, v. 6, no. 1, March, 1916.

(8) *J. S. Diller* in Science, v. 43, no. 1117, May 26, 1916.

(9) *Arthur L. Day*. Geologic history of Lassen Peak.
J. S. Diller. Volcanic phenomena at Lassen Peak.
Abstracts in Journal, Washington Academy of Sciences, June 19, 1916, **6**:404–406.

Its physics and chemistry are now being studied by A. L. Day and E. S. Shepherd, of the Geophysical Laboratory, Carnegie Institution of Washington, and will be described in a forthcoming report.

A NEW METHOD FOR DETERMINING "g" THE ACCELERATION DUE TO GRAVITY.

By HERBERT BELL, Dept. Physics, University of Michigan.

[Read before the American Physical Society, Chicago, Ill., Dec. 2, 1916.]

Consider a compound pendulum consisting of a nut of mass m, movable along a screw rod of mass M, the whole oscillating in a vertical plane about a central axis of suspension O. Denote by MK^2 the inertia of the rod about O, by mk^2 that of the nut about its center of gravity g, and by b_n the distance between O and g as projected along the rod. Suppose further that the point g is not quite collinear with the axis of the rod, but is a small distance u from this line. Then, neglecting the buoyancy and resistance of the air, we have the differential equation of motion

$$(MK^2+mk^2+mu^2+mb_n^2)d^2\theta/dt^2 = -Mhg\sin\theta - mg\,b_n\sin(\theta-\alpha_n) - C\theta,$$

where $\tan\alpha_n = u/b_n$. C is the restoring couple due to the suspension, and h the distance between O and G.

The effect of the air is twofold: (1) on account of buoyancy the restoring couple due to the weight is slightly reduced so that we must replace M and m on the right hand side of our equation by M' and m', slightly smaller quantities; (2) on account of the dragging effect these quantities on the left side must be slightly increased, say, to M'' and m'', we then have

$$(M''K^2+m''k^2+m''u^2+m''b_n^2)d^2\theta/dt^2 = -M'hg\sin\theta - m'gb_n\sin(\theta-\alpha_n) - C\theta.$$

Now the proposal is to take the time of swing T_n for various positions b_n of the nut along the screw. Thus all the constants in this equation except b_n and α_n are absolute constants. C is in any case to be very small in comparison with $M'hg$ or mb_ng.

Let us now simplify this equation by writing new constants in place of groups of constants and assuming that cubes of θ and α_n may be neglected. We thus have after dividing throughout by m''

$$(A'+b_n^2)d^2\theta/dt^2 = -\frac{M'h+m'b_n+c}{m''}g\theta + \frac{m'b_ng\alpha_n}{m''}$$

$$= -\left(B'+\frac{m'}{m''}b_n\right)g\theta + \frac{m'}{m''}g\alpha_nb_n$$